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Applied Anatomy of the Brain.

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†The Applied Anatomy of the Brain.

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Gentlemen:—

Having studied the general principles of *construction*, and the *topography* of the brain, we have now to consider this organ, or set of organs, in connection with its functions and disorders. In other words, its *applied anatomy* may properly claim our attention.

In order practically to apply our knowledge of the construction, form and relations of any organ, we require a knowledge of the work done by it in the economy. The brain may be regarded as, (1) an assemblage of nerve centers (groups of nerve cells), with (2) receiving or incoming fibres, (3) inter-communicating fibres, and (4) distributing or out-going fibres. These structures are supported and strengthened by connective tissue (neuroglia) which at the same time serves as a scaffolding for the nutrient vessels, and probably has important relations to the replacement of worn-out or destroyed nerve cells.

Nerve *centers* are capable of two fundamental or primary actions, viz: they *perceive* sensation and they *produce* force.

Nerve *endings* (peripheral or terminal organs) also exhibit two kinds of activity, viz: they *receive* impressions or they *discharge* force.

Nerve *fibres* convey impressions or force.

Hence we may simplify the scheme of the entire nervous system by considering it as a mechanism capable of five actions. A diagram may assist us here. (See Fig. 1.)

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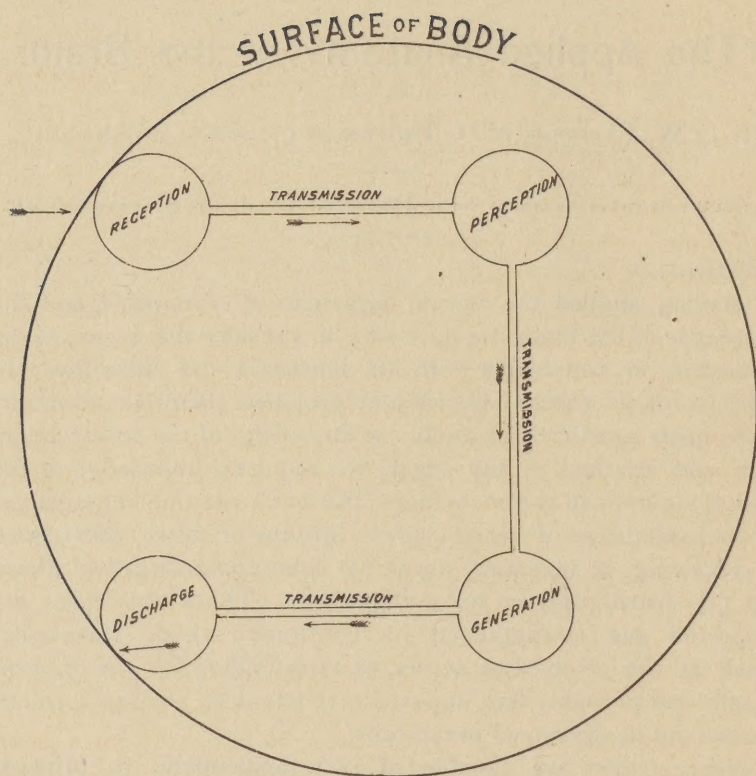


Fig. 1. Diagram to illustrate the five fundamental nervous processes.

First, we have certain nerve ends which *receive* sensory impressions, as the eye, ear, the olfactory, taste, and tactile end organs.

Second, nerve fibres *transmit* these impressions to—

Third, *perceiving* nerve cells. The Scripture reference to those “Which have eyes, and see not; which have ears, and hear not,” applies here. That would be reception without perception.

After perception, comes transmission to—

Fourth, a cell which *generates* nerve force, and then transmission again to—

Fifth, a *discharging* end organ.

The five processes then in our ideal simplified nervous system are:

Reception, transmission, perception, generation and discharge; the first and last occurring in end organs, the second in nerve fibers and the third and fourth in central cells. Reception and perception constitute the *income* of nervous activities; generation and discharge the *expenditure*.

When we come to study the subject in man, however, or in any of the higher vertebrated animals we find their nervous systems more complicated, their functions more varied, and we would require a more elaborate scheme to illustrate their activities.

The location of the different central faculties or activities in definite areas of brain cells, constitutes the science of CEREBRAL LOCALIZATION; a subject of vast interest and practical importance to the physician and surgeon.

In order to “map out” some of the more important of these areas of the brain, I place upon the board a second diagram. (See Fig. 2.)

This shows the principal cell masses as if separated in order to avoid confusion. We must bear in mind the inter-connecting nerve fibers by which they are brought into both physical and functional continuity with each other, and those other nerve fibers which pass from and to the periphery of the body. The parts shown in profile are the cortex cerebri or gray matter (nerve cells) of the cerebrum with the great basal ganglia, (the corpus striatum, optic thalamus and optic lobes) below; the cerebellum and its commissure, the pons Varolii; while extending from the pons to the foramen magnum is the medulla oblongata. Remember that the gray masses of these parts exist in bi-lateral pairs, and that our profile is intended to show one (the left) lateral half only of the brain centers.

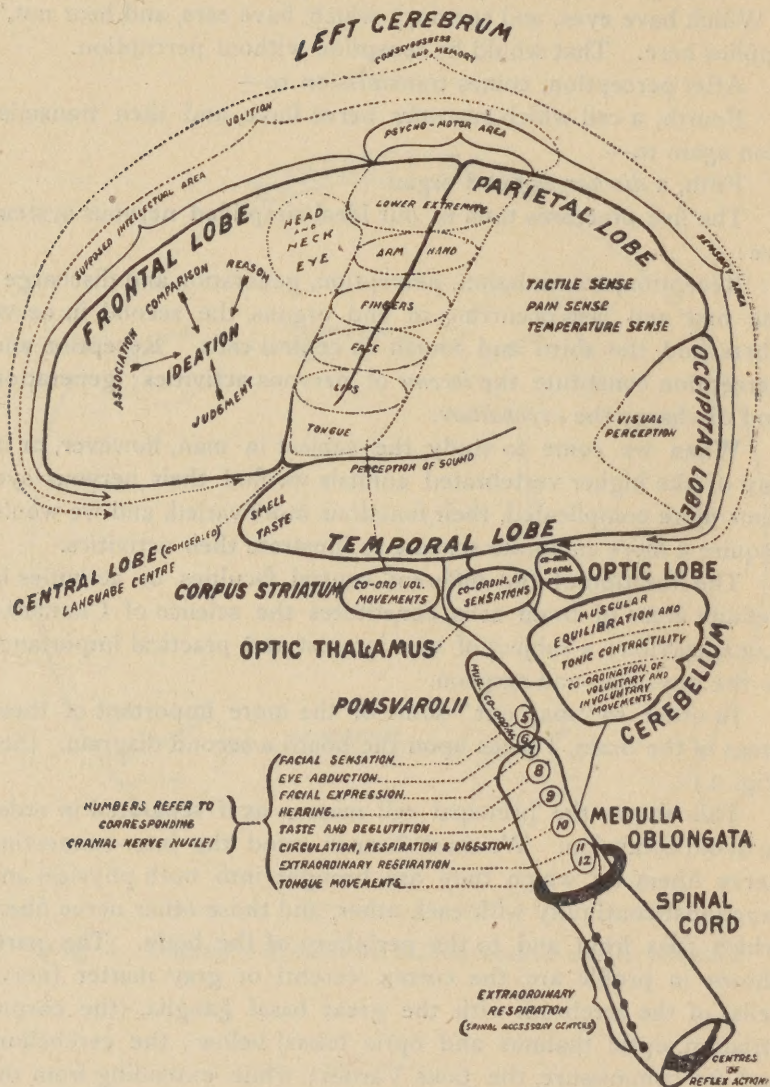


Fig. 2. Profile view of brain centres. (Diagrammatic.)

Looking at the **cerebrum** first, you will remember the great longitudinal fissure, which separates the two hemispheres of the cerebrum and which, of course, we cannot show in this profile. Then at the base of the cerebrum, and only partly visible in this view, is the fissure of Sylvius—which receives the lesser wing of the sphenoid bone; we see this fissure divide, laterally, into two unequal portions—one vertical, one horizontal. The vertical limb is the boundary between the frontal and parietal lobes, while the horizontal limb separates the parietal and temporal lobes. Running diagonally downward and forward through the parietal lobe is the fissure of Rolando, which begins at the great longitudinal fissure and ends short of the bifurcation of the fissure of Sylvius. Lastly the parieto-occipital fissure indicates the boundary between the parietal and occipital lobes. As we know, these various lobes correspond, in a general way, with the bones of the same names.

We have, in short, a large area or cap of nerve cells constituting “the convolutions” and between the convolutions sulci, or fissures; of the latter we have named the more important on the external surface. In these convolutions are located the centres for various functions; and before indicating them it may be well to explain that *two methods* are used in localizing certain functions in definite areas of cells. (1) Experimentation on healthy animals, including man, when opportunity offers. (2) Observation of symptoms in diseases and injuries of the brain, with subsequent comparison of the lesion with these symptoms.

There are also *two effects* to consider in these experiments and observations, viz: (1) Effects of *irritation* of areas. (2) Effects of *destruction* of areas. It is obvious that the two will be quite diverse in most cases.

Furthermore, there are two factors which *complicate* the study, namely: (1) Damage or irritation of nerve centres or cells, alone which would always have a definite effect. (2) The separation from this of damage to nerve *fibres* situated in the same area, but connected with quite distant and distinct centres.

Notwithstanding these and other difficulties many of the problems presented have been solved while others are yet in process of solution.

As a result of the methods referred to there has been quite definitely located on either side of the **fissure of Rolando**, a *psycho-motor area*, that is to say, an area wherein the mind directs and controls movements of the lower extremities, the arms, hands,

face, lips and tongue, as shown in our diagram; and, just in front of the arm and hand areas, is one for directing movements of the head, neck and eyes.

Then, in the **parietal lobe**, behind this motor region, is located an area which appreciates *tactile sensations*; also those of pain and temperature; and further back, in the occipital lobe, is an area for *perception* or *interpretation* of vision; without it the most perfect eyes would be of no use to us.

Passing to the **temporal lobe**, we find here located in its upper convolution, perception or analysis of *sound*, while *smell* and *taste* are very near neighbors in the "tip" of the same lobe. We see, then, that the five senses are located in that portion of the cerebrum which lies behind and below the motor area. In other words, this is the seat of consciousness of these sensations.

We still have the **frontal lobes** (excepting the ascending frontal and part of the inferior, middle and superior frontal convolutions) blank; but we may feel sure they do not exist without a use. There are good reasons to believe, while it cannot be considered proven, that in these frontal lobes anterior to the motor area, are located some, if not all, of the faculties comprehended under the term higher *intellectual* or the power of abstract ideation, resulting from comparison, reason and judgment; faculties which, in their highest development, are found only in man. Hence the difficulty of proving their location by experiment on lower animals. We must locate these faculties, therefore, mainly by exclusion, just as it is sometimes necessary to diagnose a disease in this way. This is not so satisfactory as diagnosis by direct evidence, yet it is a scientific method when we have no other. Briefly, the best reasons for locating the higher intellectual faculties in this pre-frontal region are: (1) Sensation and motion are not affected by its destruction; and (2) the great development of this region and its assigned functions in man as compared with lower animals.

We may call this, then, the supposed intellectual area.

As there are no straight lines in nature it follows that these various areas shown overlap each other, to a greater or less extent; thus the tactile area, as shown by our dotted line, overlaps or spreads into the motor region. It would be natural to expect that it would; for it is necessary that movement, to be conducted intelligently, must be associated with sensation. It would be very embarrassing, for instance, for us to walk in the dark without the sense of touch to warn us of danger.

The subject of *locomotor ataxia*, as you have seen, experiences this same embarrassment until he learns to substitute his visual sense for impaired tactility. Hence, we tell him to close his eyes in order to bring out his peculiar gait.

Volition, or the power of *will* over thought and motion, is a faculty which it would be interesting to locate. We can not admit that will power has any great influence over sensation. You may modify sensation perhaps, but you can not do away with it or increase it greatly by any effort of will. If the visual organs are all healthy and active, you must see; the same is true of the other senses. We must therefore exclude will from the sensory area. We draw the line of volition then, so as to include the intellectual and motor areas; here will power may be located; it probably is not confined to narrower limits.

Memory is another important faculty of nerve centres. We may remember all kinds of sensations, motions and processes of intellection. Hence, we may conclude that the faculty of memory is distributed over the entire cortical area; in other words memory cells probably exist throughout the sensory, motor and intellectual regions. We include them all in our memory line accordingly, and *consciousness* must be at least co-extensive with memory.

Let me now turn your attention to the **Basal Ganglia** or larger masses of nerve cells located deeply in the cerebrum, viz: the corpora striata, optic thalami and corpora quadrigemini or optic lobes.

Experiment seems to show that the **corpus striatum** is related to the *co-ordination of voluntary movement*; thus, when the hunter raises his gun to shoot at a rabbit, the muscles of the shoulder, arm, hand, fingers and face all act together as one system, for the time being. This harmonious association of action constitutes voluntary co-ordination, and is one of the functions affected when the gray matter alone of the corpus striatum is damaged. If nerve fibers going to other areas be involved, the diagnosis is correspondingly complicated.

As to the **optic thalamus**, there are good reasons for the belief that it is a *co-ordinating centre for certain sensory functions*; thus, in the illustration just cited, the image of the rabbit upon the visual centres, and the sense of the finger upon the trigger, are associated sensations. Again, when the small boy looks into the shop window at the Christmas candies, his "mouth waters,"—in other words, co-ordination occurs between centres of sight and taste. So

the odor of a rose or violet may bring up a mental image of the corresponding flower.

The **corpora quadrigemini** (optic lobes) seem to be largely occupied with the *co-ordination of visual movements*, as accommodation for distance, contraction and dilatation of the pupil, etc.; hence their great comparative size, in birds generally, and in birds of prey especially, which exercise these functions to a greater degree than other vertebrates.

Leaving the cerebrum and its basal ganglia, with this glance at some of their more important functions, let us turn our attention to the **cerebellum**. The gray matter of this ganglion seems to preside over (1) *co-ordination of muscular equilibration* e. g., the locomotory balancing of the body so to speak, in walking, a process similar to the functions of the corpus striatum, with which it is directly associated by tracts of nerve fibres. Its extensive and numerous anatomical relations with both sensory and motor centres and fibre tracts, render its various functions extremely difficult of isolation; hence it has been called "the *terra incognita*" of the brain. Evidences, inconclusive in character however, have been adduced to show that it presides over *all* tonic (as distinguished from clonic) muscular contractility, as in maintaining a fixed attitude for any time, and the tonic contraction of involuntary muscular fiber in the walls of the heart, the blood vessels, fallopian tubes, the uterus, the vas deferens, the stomach and œsophagus, etc. Thus we may explain the staggering gait, persistent vomiting, and irregular heart action, often present in cases of cerebellar tumor.

The cerebellum is also thought to possess functional connections with the semi-circular canals of the ear, and with the visual and tactile centres. The relationship between these and equilibration is obvious. It has been termed "the servant of the cerebrum" (Ranney), attending to these duties when its master is otherwise engaged, but liable to have its work supervised or interfered with at any time by the governing centres.

The **pons Varolii** like the cerebellum is so intimately associated with adjoining parts as to render its intrinsic functions obscure. Thus it is the "bridge" or commissure, by means of its transverse fibers, between the lateral halves of the cerebellum, while its longitudinal fibers connect the cerebrum and its crura above, with the medulla oblongata below. In addition to these fibers it includes isolated masses of nerve cells in its interior, as well as a layer of

gray matter which forms its upper surface, and consequently the anterior portion of the floor of the fourth ventricle. This last layer of nerve cells is simply a continuation upward of the central gray matter of the spinal cord, and forms an unbroken expanse of nerve cells, extending from the spinal cord below through the fourth ventricle, the iter, the third and lateral ventricles, to the infundibulum and the lamina cinerea.

On account of their intimate connections, both anatomical and functional, it is convenient to consider the applied anatomy of the pons and the medulla together.

Briefly stated, this region is, in a vital sense, the most important in the brain, since the gray matter forming the upper surface of the medulla and the pons contains centres governing circulation, respiration and digestion; and may modify in an important manner the secretion of the kidneys, (probably through the digestive function) as shown by the well-known experiment of producing glycosuria by irritation of this centre.

Moreover, from this same region come the cranial nerves, from the 5th to the 12th inclusive, representing centres influencing facial sensation (5th), eye abduction (6th), facial expression (7th), hearing (8th), taste and deglutition (9th), circulation, respiration and digestion (10th), phonation (11th via 10th), extraordinary respiratory movement (11th), and tongue movements (12th). We must remember too, that most of these oblongata centres are probably re-inforced by the sympathetic ganglia and spinal centres. In the medulla also, the decussation occurs of motor fibres passing from the cerebrum to the periphery, through the crura, pons, medulla and spinal cord. To this crossing is due the fact that the effects of lesions of the psycho-motor area are manifested on the side of body opposite the lesion; a left sided lesion, producing, as a rule, right-sided paralysis and *vice versa*.

In closing this brief survey of the more important brain areas and functions, we must bear in mind the inter-connection by means of nerve fibres (*cell processes*) of these apparently isolated centres, and their further connection with the periphery of the body, by means of other fibres, transmitting in-coming and out-going nerve currents.

Now, gentlemen, the anatomy of a clock may be very interesting in itself, but is of little practical use to the average men unless the wheels and hands may be put together and made to tell the time of day.

In order to apply some of these facts, and to blend together

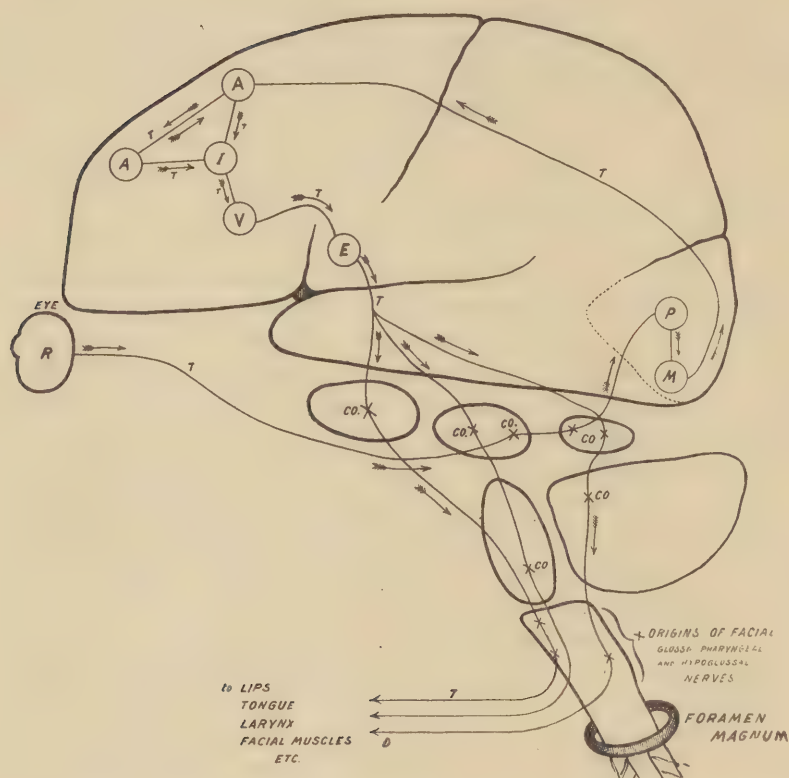


Fig. 3. Diagram to illustrate the anatomy of a train of thought and its expression.

R—Receiving end organ (eye).

T—Transmitting fibres.

Co—Co-ordinating centres or cells.

P—Perception cells, for visual impulse.

M—Memory cells.

A—Association cells (comparison, reason, judgment).

I—Ideation cells.

V—Volition cells.

E—Expression cells (centres for articulate speech).

Arrows indicate direction of nerve currents.

Crosses indicate co-ordinating areas.

in a comprehensive way, some of these apparently scattered and disconnected working elements of the brain, suppose we consider for a moment, the succession of nervous activities which occurs in the elaboration and expression of an ordinary thought. We may call this

THE ANATOMY OF A TRAIN OF THOUGHT,

the anatomical order of its processes. A diagram may assist us here. (See Fig. 3.)

First of these processes is *reception* (R) of a sensory impression. As income must precede expenditure, so must sensation precede ideation and expression. We will suppose the impression received by the eye. The next process is *transmission* (T) of the impression through appropriate co-ordinating centres (Co) to a centre of visual *perception* (P) in the occipital lobe; nerve fibres you will remember are the transmitting organs. Perception having occurred, to be useful, must be remembered. *Memory* (M) then, is the third process in nerve cells. We will suppose that there is a layer of memory cells in the visual centre, which is probably true; and we transmit the impulse accordingly. Now, it is almost impossible to remember a fact, without associating it with some other fact or idea. *Association* (A) (mental co-ordination), is our fourth process. We may locate it, provisionally in the pre-frontal region; by means of association we compare, reason and form judgments of facts or ideas. Fifthly, the outcome of this association may be a new idea, or another mental image; in other words *ideation* (I) or *conception* occurs.

Do we wish to use this new idea? We must come to that conclusion by an exercise of will power. *Volition* (V) then, is the sixth process. This may be located anywhere in front of the sensory regions.

The seventh process is *expression* (generation and discharge of motor force) this may be affected by language, (i. e. gesture, speech or writing,) or by facial or locomotory action, all modes of motion.

In case it is to be spoken, it comes to the third frontal convolution of the left hemisphere, the speech centre; whence it is transmitted to the points of discharge (D) by way of various co-ordinating centres (Co).

We may express this scheme of action in another way. (See Fig. 4.)

Some such chain of action, in reality vastly more complex than here represented, is repeated hundreds, perhaps thousands of times a day in the brain of the average man; coincident with it is.

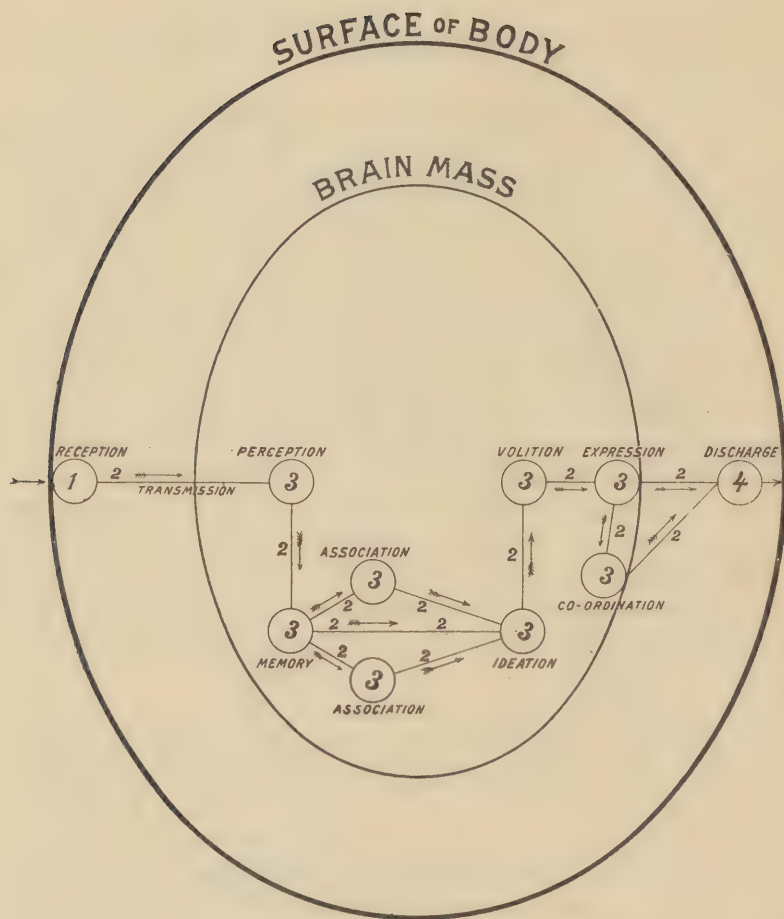


Fig. 4. Diagrammatic scheme of processes constituting the simplest train of thought and its expression.

- 1.—Receiving end organ (sensory).
- 2.—Transmitting fibres.
- 3.—Central activities proper.
- 4.—Discharging end organ (motor).

the constant outflow of nervous force to the co-ordinating, the circulatory, respiratory and digestive organs.

If it be possible for one object in nature to be more wonderful than another, I think you will agree with me that the brain—the only machine that can think—is the most wonderful mechanism in existence.

Day after day and year after year, from the dawn of infancy, through the morning of youth, to the noon day of maturity, these processes go on with ever increasing scope and complexity; the late afternoon of life even, may find them in full vigor. Sooner or later however, the shades of evening begin to draw a veil o'er the scene of nervous action; the nerve centres begin to fail and it is a most remarkable fact that this failure is seldom or never due to the actual wear and tear of the nervous tissues themselves.

The hand of time lays its impress heavily upon the circulatory system, however, producing changes in the blood vessels which seriously affect the nervous structures. To refer to these changes briefly, the walls of the vessels weaken as a result of long-sustained pressure and fatty degeneration; nature seems to attempt compensation by thickening these walls, a substitution of quantity for quality. As a result of this thickening their calibre lessens and their elasticity diminishes; less blood is conveyed to the tissues and by a slower current. Soon there is barely room in many of the minute vessels of the nerve centres for a blood corpuscle to pass; enough fluid to sustain life in the tissue, but little to spare for other functions. Waste exceeds repair and nutrition wanes.

As a sequence to this impaired nutrition the sense organs concerned in *reception*, lose their acuity, *transmission* is slowed, *perception* blunted: *memory*, especially for recent events, is fleeting, *ideation* is sluggish; *association* of ideas is less active, *volition* weak and *expression* imperfect. Muscular co-ordination, so essential to all forms of expression is less precise, as shown by the trembling hand, the faltering gait and the quavering voice. The muscles of the trunk lose their accustomed tension, the form is bowed, the eye is fixed on the stumbling feet, and

“The sixth age shifts

Into the lean and slippered pantaloen,

With spectacles on nose and pouch on side;

His youthful hose well saved a world too wide,

For his shrunk shank; and his big, manly voice,

Turning again toward childish treble, pipes

And whistles in his sound.”

Finally, the life current ebbs and ceases in the circulatory or respiratory centres; and the twilight of life deepens gradually into the darkness of death, without pang or struggle. The day is ended, "the race is run," the light is out.

Such is the normal course of events, and it should not be looked upon with horror or dread. Natural death by the brain is not painful, mentally or physically; it is like going to sleep.

A far different picture, however, may present itself. As the brightness of the summer afternoon may be marred by a thunder cloud, so may this harmonious cycle of nervous activities be interrupted by disease storms, with effects varying, from the slightest temporary inco-ordination to the most profound impairment of structure and function, dethroning life itself.

At another time we may consider some of these *interruptions* to the natural course of events.

